PHY 131 HW V Solutions

1. Initial position 5m east, 3m n. Let's call E/W the x coordinate w/ E positive, and N/S the y coordinate w/ N positive. So our position is

$$(x_0, y_0) = (5, 3) \quad \text{in meters.}$$

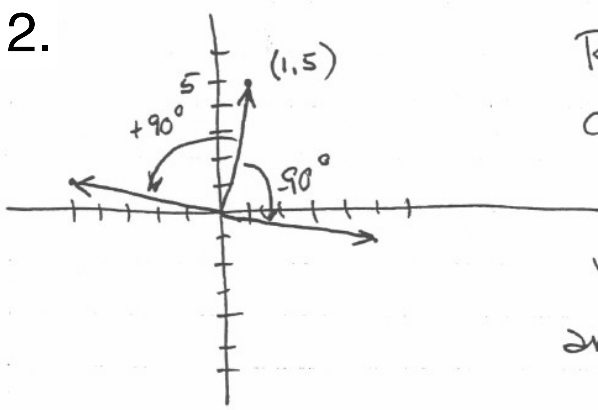
We now move 3m west (-3 in the x direction) and 10m South (-10 in the y direction), so

$$(x_{new}, y_{new}) = (5, 3) + (-3, -10) = \boxed{(2, -7)}, \text{ so}$$

2m E, 7m S of our starting point. Distance from the origin can be found by Pythagoras:

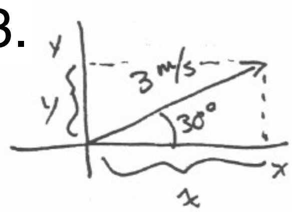
$$\text{distance} = \sqrt{x^2 + y^2} = \sqrt{(2)^2 + (-7)^2} = \sqrt{53} = \boxed{7.28\text{m}}$$

2.



Rotating $(1,5)$ by $\pm 90°$ changes $x \to \mp y$ and $y \to \pm x$, so the two perpendicular vectors of the same length are $\boxed{(5,-1) \text{ and } (-5,1)}$

3.



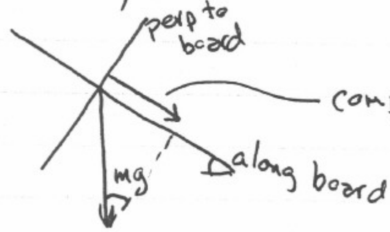
If I move 3 m/s for 5 sec, I have moved a total distance of 15m. Then, I take x & y components:

$$x = 15\text{m} \cdot \cos 30° = \boxed{13\text{m}}$$

$$y = 15\text{m} \cdot \sin 30° = \boxed{7.5\text{m}}$$

4.

a) To find component along board – this is effectively defining a new coordinate system:



component along board is $mg\sin\theta$

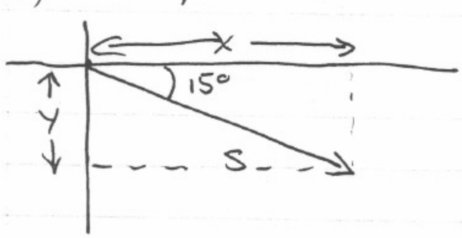
$F_{along} = (.5\,kg)(10\,m/s^2)\cdot\sin 15°$

$\boxed{= 1.29\,N}$

b) $a = F/m = \dfrac{1.29\,N}{.5\,kg} = \boxed{2.59\,m/s^2}$

c) $s = \frac{1}{2}at^2 = \frac{1}{2}\cdot 2.59\,m/s^2\cdot t^2 = \boxed{1.29\,m/s^2\cdot t^2}$

d) Now, we are returning to conventional x-y coords



$x = s\cdot\cos 15°$

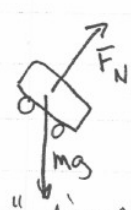
$= 1.29\,m/s^2\cdot t^2\cdot(.966) = \boxed{1.25\,t^2}$

$y = s\cdot\sin(-15°)$

$= 1.29\,m/s^2\cdot t^2\cdot(-.259) = \boxed{-.33\,t^2}$

This is a y acceleration of only $-.66\,m/s^2$, <u>not</u> $-9.8\,m/s^2$.

This is because $-mg\hat{y}$ is <u>not</u> the only force acting on the cart – the board exerts a normal force (contact force) $\perp$ to the board, as shown in the figure at right (this is usually & misleadingly called a "free body" diagram)



F_{net} in the y direction i much less than -m

5.

The x component of velocity is constant:

$$v_x = v_{0x} = 10\,\tfrac{m}{s}\cdot\cos 45^\circ = 7.07\,\tfrac{m}{s}$$

so, to travel 10m takes $\Delta t = \frac{\Delta x}{v} = \frac{10\,m}{7.07\,m/s} = \boxed{1.4\,sec}$

Once we have this time, we can use it in ~~t~~ the y equation to find the ball's change in height:

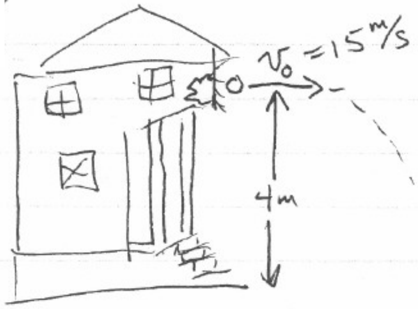
$$\Delta y(t) = \tfrac{1}{2}a_y t^2 + v_{0y}t = -5\,\tfrac{m}{s^2}t^2 + 10\,\tfrac{m}{s}\cdot\sin 45^\circ\, t$$

$$= -5\cdot(1.4\,sec)^2 + 10\,\tfrac{m}{s}\cdot(.707)\cdot(1.4\,sec)$$

$$= -10\,m + 10\,m = 0$$ → comes back in this case at exactly the same height!

You were not asked to show this. Note that if my friend was, say, 7m away, the ball would have gone over her head!

6.



x component

$$x(t) = v_{0x}t + \cancel{x_0}^{\,0}$$

$$= 15\,\tfrac{m}{s}\,t$$

y component

$$y(t) = -\tfrac{1}{2}gt^2 + \cancel{v_{0y}}^{\,0}t + \cancel{y_0}^{\,4m}$$

$$= -5\,\tfrac{m}{s^2}t^2 + 4\,m$$

a) When hit? use $y(t) = 0 = -5\,\tfrac{m}{s^2}t_{hit}^2 + 4\,m$

so $t_{hit} = \sqrt{\frac{4\,m}{5\,m/s^2}} = \boxed{0.89\,sec}$

b) How far? use $x(t) = 15\,\tfrac{m}{s}\cdot t = 15\,\tfrac{m}{s}\cdot 0.89\,sec = \boxed{13.4\,m}$